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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of: Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band	IB Docket No. 95-91 GEN Docket No. 90-357

Supplemental Comments of Sirius Satellite Radio

Sirius Satellite Radio Inc. ("Sirius"; formerly CD Radio Inc.) files these supplemental comments to confirm the lack of harmful interference to other licensed radio services from the terrestrial repeater component of its satellite digital audio radio service ("satellite DARS") system and to urge the FCC to adopt promptly terrestrial repeater licensing rules.[1] Adopting licensing rules for terrestrial repeaters is the Commission's sole remaining task in this proceeding.[2]

Almost a decade has passed since the FCC initiated its inquiry on satellite DARS.[3] During that time, the Commission has taken nearly every substantive and procedural step

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[1] Satellite DARS systems require limited use of terrestrial repeater stations to provide signal coverage to areas where satellite transmissions are blocked or subject to severe multipath interference, particularly in so-called "urban canyons" between tall buildings.

[2] *See Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band*, 12 F.C.C. Rcd 5754, 5810-12 (1997) (Report and Order, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking) ("*DARS Licensing Order and Further NPRM*").

[3] *Amendment of the Commission's Rules with Regard to the Establishment and Regulation of New Digital Audio Radio Services*, 5 F.C.C. Rcd 5237 (1990) (Notice of Inquiry).

required for the initiation of service. Notably, the agency has allocated spectrum to satellite DARS,[4] assigned the spectrum in two equal shares through a competitive bidding process,[5] adopted satellite DARS service rules,[6] and proposed licensing rules for terrestrial repeaters.[7] As part of these actions, the Commission decided that terrestrial repeaters are essential to fulfill the public interest of satellite DARS systems,[8] and expressly defined the satellite DARS service to include terrestrial augmentation.[9] The FCC also adopted the suggestion, originally proposed by

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[4] *Amendment of the Commission's Rules with Regard to the Establishment and Regulation of New Digital Audio Radio Services*, 10 F.C.C. Rcd 2310 (1995) (Report and Order).

[5] *See FCC Announces Auction Winners for Digital Audio Radio Service*, 12 F.C.C. Rcd 18727 (1997) (Public Notice); *Satellite CD Radio, Inc., Application for Authority to Construct, Launch and Operate Two Satellites in the Satellite Digital Audio Radio Service*, 13 F.C.C. Rcd 7971 (1997) (Order and Authorization); *American Mobile Radio Corporation, Application for Authority to Construct, Launch, and Operate Two Satellites in the Satellite Digital Audio Radio Service*, 13 F.C.C. Rcd 8829 (1997) (Order and Authorization).

[6] *DARS Licensing Order and Further NPRM,* 12 F.C.C. Rcd at 5787-805, and Appendix A.

[7] *Id.* at 5810-12. Sirius suggested revisions to the agency's proposed terrestrial repeater licensing rules in its initial comments. Comments of CD Radio at 4-5 and Attachment (filed June 13, 1997). Sirius continues to believe that its suggested revisions better fulfill the FCC's stated conclusion that satellite DARS licensees should be exempt from "seek[ing] separate authorization for each terrestrial repeater." *DARS Licensing Order and Further NPRM,* 12 F.C.C. Rcd at 5812. Accordingly, Sirius submits, as Exhibit 3, revisions to the terrestrial repeater licensing rules proposed as Section 25.144(e) in Appendix C of the *DARS Licensing Order and Further NPRM.* These proposed revisions contain slight improvements to the revisions suggested in 1997.

[8] *DARS Licensing Order and Further NPRM,* 12 F.C.C. Rcd at 5812 (proposing "to permit deployment of satellite DARS gap-fillers, on an as-needed basis by satellite DARS licensees to meet their service requirements"). *See also id.*, proposed rule 47 CFR § 25.201 (definition of "satellite DARS").

[9] *Id.* at 5770 ("It has been widely known and discussed in the record that DARS providers will need to rely on terrestrial repeaters and gap fillers").

Sirius, that repeaters broadcast the same programming that is on the satellite,[10] thereby confirming that terrestrial-only systems may not be implemented in the licensed spectrum.

The *DARS Licensing Order and Further NPRM* in the present proceeding merely addresses procedural rules for how repeaters would be authorized. The Commission needs to finalize these rules in a fashion sufficiently timely to ensure repeaters are constructed when satellite DARS service commences.

Sirius has made use of the time elapsed from the start of this proceeding to improve its satellite DARS system, including its terrestrial repeater technology. Sirius is FCC-licensed to provide satellite DARS to the continental United States from two Geostationary platforms, and has applied to the Commission to modify its constellation to three satellites in geosynchronous orbit.[11] Sirius's satellite construction is nearly complete and its first launch is scheduled early this year. As its spacecraft become operational, Sirius plans to install terrestrial repeaters by year-end 2000 as needed to ensure the public's uninterrupted access to this promising new service. Sirius initially will need repeaters operating up to 46 dBW EIRP (i.e., 40 KW EIRP) at approximately 105 sites in the urban cores of 46 cities.[12] In addition, Sirius will employ

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[10] *Id.* at 5812 (reaching the "tentative conclusion to prohibit the use of terrestrial repeaters to transmit locally originated programming").

[11] Satellite CD Radio, Inc., Application to Modify Authorization to Launch and Operate a Digital Audio Radio Satellite Service in the 2320.0 - 2332.5 MHz Frequency Band (filed Dec. 11, 1998); *See Satellite Policy Branch Information Applications Accepted for Filing*, Report No. SAT-00009 (Jan. 7, 1999) (Public Notice) (accepting Satellite CD Radio, Inc.'s application for filing and assigning file number SAT-MOD-19981211-00099). Sirius anticipates that this pending request will be granted soon.

[12] Although Sirius anticipates deploying some low power sites and additional very low power coverage extenders, this analysis herein assumes the worst case scenario of 46 dBW EIRP.

additional very low power radiators to overcome other local obstructions, such as tunnels, long underpasses, and ravines. In light of this fast approaching service date, Sirius respectfully requests that the FCC issue without delay a Report and Order establishing blanket licensing rules for terrestrial repeaters.

Sirius terrestrial repeaters will not cause harmful interference to other radio services. Sirius has already shown that its satellite and terrestrial transmissions meet the out of band emissions requirements of 25.202(f). Attached hereto, for inclusion in this rulemaking record, are interference studies that demonstrate that terrestrial repeaters in Sirius's system will not cause harmful interference to adjacent and near-adjacent band radio services, including the wireless communications service ("WCS"), the multipoint distribution service ("MDS"), the multichannel multipoint distribution service ("MMDS"), and the instructional fixed television service ("ITFS"). As shown in the Exhibits, the sophisticated spectral shaping and extensive filtering achieve very low out of band emissions.

As shown in Table 1, the FCC licensed two satellite DARS systems, Sirius and XM Satellite Radio Inc. ("XM"), for the 2320-2332.5 MHz and 2332.5-2345 MHz bands, respectively. The Commission also allocated the bands 2305-2320 MHz and 2345-2360 MHz to WCS and the bands 2150-2162 MHz and 2500-2690 MHz to the MDS (including MMDS and ITFS).[13] Sirius's terrestrial repeaters will operate in the sub-band 2324.25-2328.25 MHz, which is in the middle of Sirius's assigned frequency band. This design configuration increases the frequency separation between Sirius's repeaters and other terrestrial radio services in adjacent and near-adjacent bands and, accordingly, significantly reduces interference potential.

[13] For simplicity, the abbreviation MDS is used throughout this filing to refer to all three services.

<table>
<tr><td>2305 MHz</td><td colspan="3">2320</td><td colspan="3">2332.5</td><td>2345 / 2360</td></tr>
<tr><td rowspan="3">WCS</td><td>Sat.</td><td>T.R.</td><td>Sat.</td><td>Sat.</td><td>T.R.</td><td>Sat.</td><td rowspan="3">WCS</td></tr>
<tr><td colspan="3">Sirius</td><td colspan="3">XM</td></tr>
<tr><td colspan="6">Satellite DARS</td></tr>
</table>

Table 1.
("Sat." = satellite downlinks; "T.R." = terrestrial repeaters)

The typical waveform shape for Sirius's terrestrial repeaters is shown in Figure 1 and Figure 2 below. Note that with a total EIRP of 46 dBW for the 4 MHz waveform bandwidth, the EIRP spectral density drops from 40 dBW / 1 MHz at the repeater's center frequency to -75 dBW / 1 MHz at the edges of Sirius's assigned band. The power drops another 20 dB (to -95 dBW / 1 MHz) further away from the center frequency.

Figure 1 - Typical Sirius Transmit Waveform Shape (max power, low side)

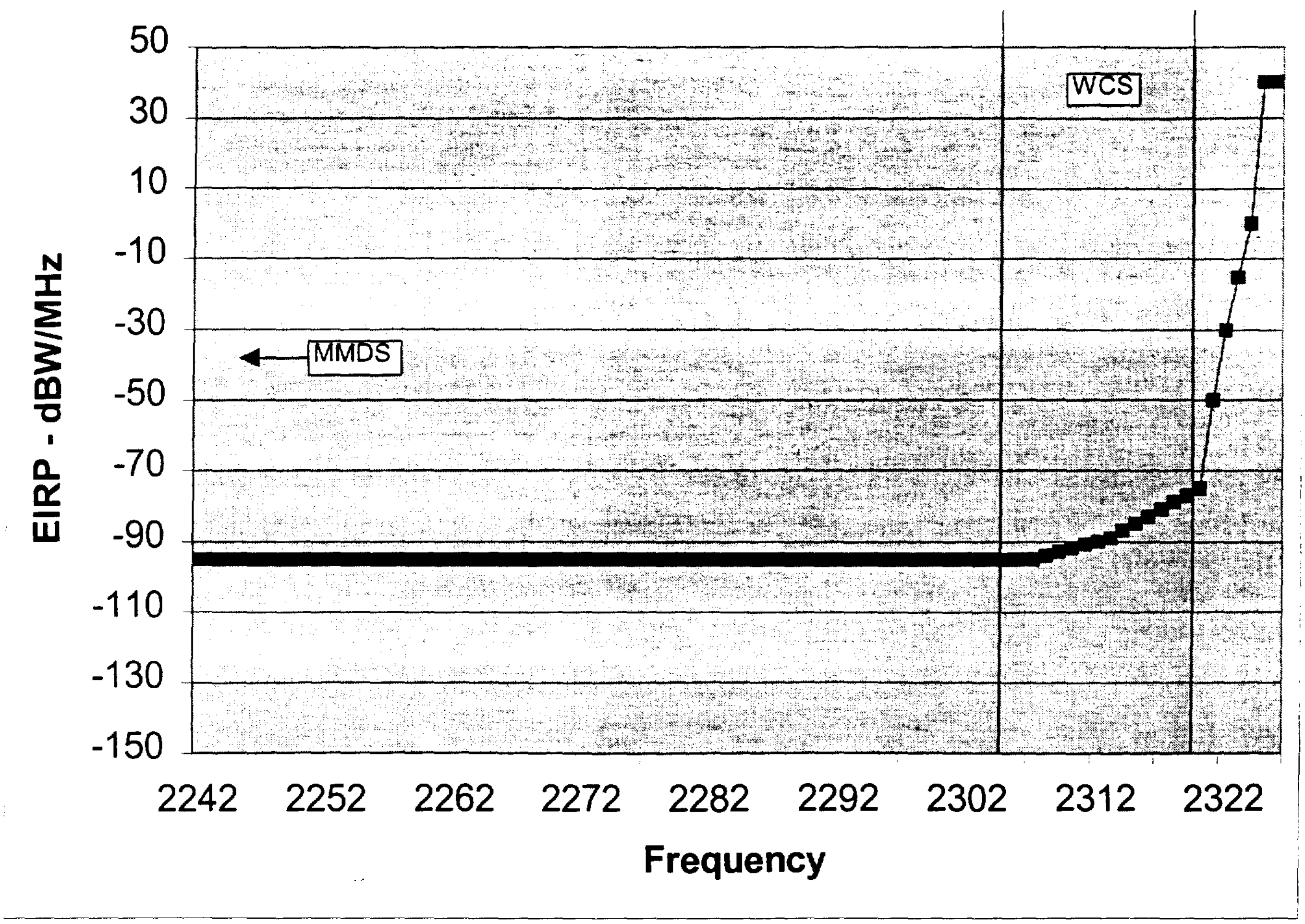
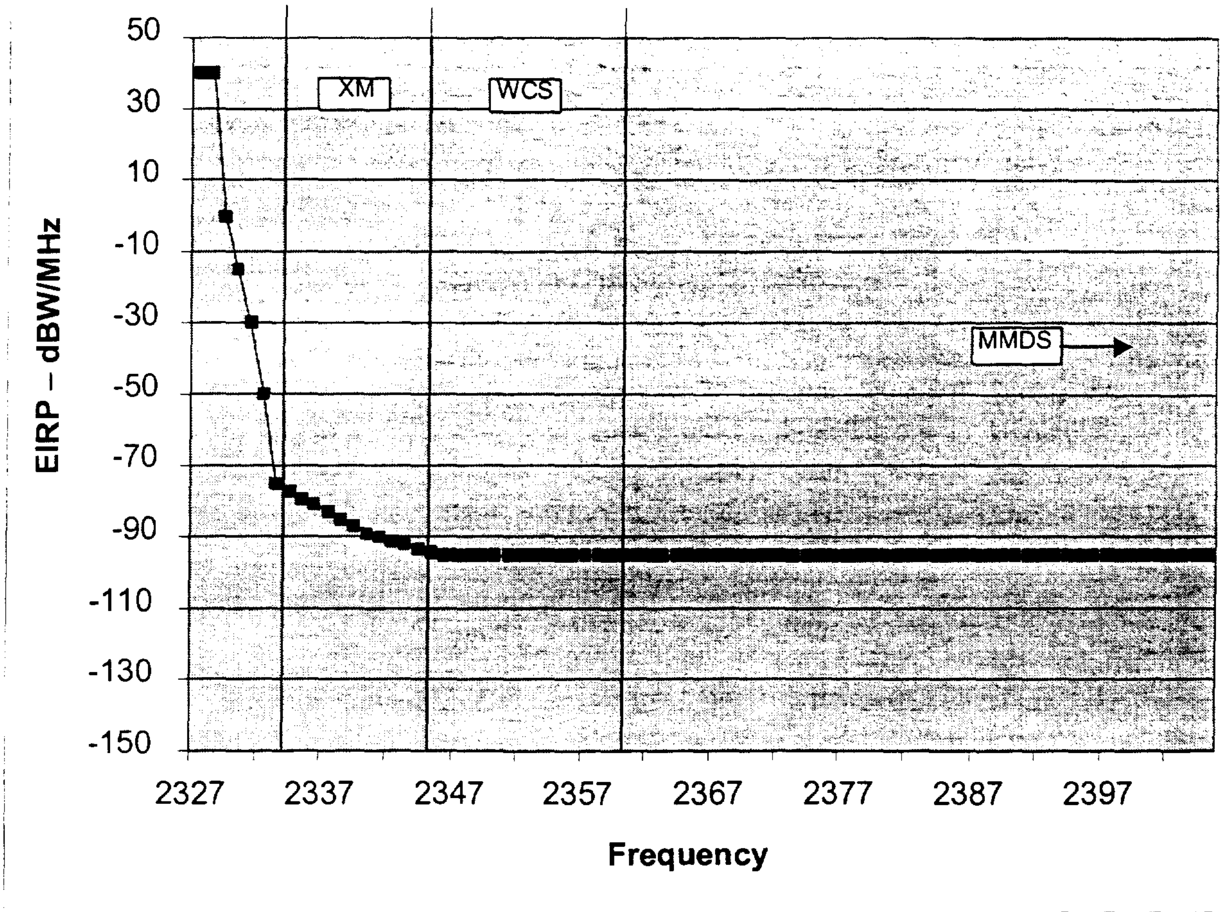


Figure 2 - Typical Sirius Transmit Waveform Shape (max power, high side)



Because Sirius purchased at auction rights to use the lower frequency band of the two satellite DARS licensees, the worst-case potential interference from Sirius's terrestrial repeaters is to WCS systems in the lower adjacent WCS band, 2305-2320 MHz, and to MDS systems in the 2150-2162 MHz MDS band. We discuss each in turn below.

WCS: The WCS interference analysis, attached as Exhibit 1, first describes how the maximum emissions from Sirius's terrestrial repeaters into the lower WCS band (2305-2320 MHz) will be no higher than -75 dBW / 1 MHz. This power is far (32 dB) lower than the

-43 dBW / 1 MHz power spectral density individual WCS systems must accept from each other pursuant to FCC rules.[14] In other words, WCS systems will receive no harmful interference from Sirius terrestrial repeaters because the interference WCS systems receive from each other will entirely overshadow any interference received from Sirius.

The WCS analysis next examines in detail how emissions from one WCS transmitter might interfere with a receiver in a different WCS system and, then, how emissions from a Sirius terrestrial repeater might interfere with such a receiver. The three basic types of WCS systems (point-to-point fixed, point-to-multipoint fixed, and mobile) were considered. For each type, analysis was conducted for each of two or three antenna gains.

The results of the analysis are summarized in Table 2. Each of the five rows of data corresponds to a potentially interfering transmitter; each of the seven numbered columns represents a potentially interfered with receiver. The first data row is for a potentially interfering mobile WCS system; the next two are for potentially interfering WCS point-to-point or point-to-multipoint transmitters in two scenarios; the next two rows are for potentially interfering Sirius terrestrial repeaters in the same two scenarios.

In one scenario, the transmitting and receiving antennas are located 10m from one another, such as could occur if one were right above the other on a common transmitter tower or building and both were pointing roughly horizontally. This configuration is noted as "overhead" in Table 2. In the other key scenario, transmitting and receiving antennas are oriented mainbeam-to-mainbeam to each other at a distance of 100m. This configuration is noted as "boresight," which is rare in practice because of the narrow beam antennas employed. For the

[14] 47 C.F.R. § 27.53.

seven columns representing potential victim WCS receivers, there are multiple configurations for the point-to-point, point-to-multipoint, and mobile receivers.

As the results indicate, the worst case carrier-to-interference (C/I) ratio caused by Sirius terrestrial repeaters is 58 dB. In contrast, WCS mobile transmitters can create C/I ratios as low as 0.0 dB to WCS point-to-point receivers. In *no case* are satellite DARS repeaters the dominant interference source. Thus, Sirius terrestrial repeaters will not cause harmful interference to WCS operations, because they already have to accept a far higher level of interference from each other.

Interfered-With Receivers

Interfering Transmitter

	Column No.:	1	2	3	4	5	6	7
		PP (1) (dB)	PP (2) (dB)	PMP (1) (dB)	PMP (2) (dB)	PMP (3) (dB)	M (1) (dB)	M (2) (dB)
WCS Mobile	Nearby	0.0	0.0	6.0	6.0	6.0	6.0	6.0
WCS PP/PMP	Overhead	44.3	24.8	38.3	30.8	14.7	14.7	14.7
WCS PP/PMP	Boresight	5.0	5.0	11.0	11.0	11.0	11.0	11.0
SSRR	**Overhead**	**88.7**	**68.2**	**81.8**	**74.3**	**58.1**	**58.1**	**58.1**
SSRR	**Boresight**	**62.0**	**62.0**	**68.0**	**68.0**	**68.0**	**68.0**	**68.0**

Table 2.
C/I for Various WCS Interference Conditions (values in dB).
(PP = point-to-point; PMP = point-to-multipoint; M = mobile; SSRR = Sirius Satellite Radio repeaters)

MDS: A similar analysis – examining both "overhead" and "boresight" orientations – of potential interference from Sirius terrestrial repeaters to MDS receivers was conducted. As described in Exhibit 2, Sirius terrestrial repeater EIRP emissions are attenuated more than 20 dB to less than –95 dBW/MHz at the closest edge of the MDS bands (2162 MHz).[15] This analysis, described in Exhibit 2, also concludes that at negligible separation distances the terrestrial repeaters will cause no harmful interference either to old analog MDS systems or to newer digital systems (including narrow-band operations) in the 2150-2162 and 2500-2690 MHz bands. The results are summarized below in Table 3.

	Digital MDS (Industry Recommended C/I = 27 dB)	**Analog MDS** (Industry Recommended C/I = 45 dB)
Scenario 1 (sidelobe)	0.1 m	0.4 m
Scenario 2 (boresight)	4.2 m	15.3 m

Table 3.
Separation Distances Needed to Meet MDS Industry Recommended C/I Ratios

In particular, the MDS study concludes that a Sirius terrestrial repeater transmitting antenna would need to be located less than half a meter from an MDS receiving antenna (for either a digital or analog MDS system) before causing harmful sidelobe-to-sidelobe interference.

[15] This corresponds to a transmitter emission level of –111 dBW / MHz.

And for the boresight-to-boresight condition, a Sirius terrestrial repeater would need to be located within 4.2 meters of a digital MDS antenna and 15.3 meters from an analog MDS antenna before the industry-recommended C/I ratio would be degraded. Even this degradation can be avoided in numerous ways including not co-locating a Sirius terrestrial repeater with an MDS transmitter. Given the extreme unlikelihood that these conditions ever would be realized unintentionally, it is safe to conclude that Sirius terrestrial repeaters will cause no harmful interference to MDS systems in 2150-2162 and 2500-2690 MHz bands.

Attached as Exhibit 4 is a report on the Sirius tests and measurements conducted in San Francisco and Houston. This report also contains a demonstration that Sirius terrestrial repeaters can be operated consistent with the FCC rules for hazardous radiation.

* * *

In view of the fact that Sirius is on the brink of offering satellite DARS service, Sirius respectfully urges the FCC to close, as soon as possible, this proceeding and issue a Report and Order adopting blanket licensing rules for terrestrial repeaters. The information provided herein and in the attached interference studies confirms that no harmful interference to adjacent band radio services will result. This includes XM where we have agreed that the out-of-band emission limits stated herein will be sufficient to avoid significant interference with each other's service.

Accordingly, the FCC should proceed to adopt the final rules it proposed, as modified by Sirius in Exhibit 3.

Respectfully submitted,

Sirius Satellite Radio Inc.

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CERTIFICATION OF PERSON REVIEWING TECHNICAL INFORMATION

I am the Executive Vice President Engineering of Sirius Satellite Radio, the parent company of Satellite CD Radio, Inc. I certify that I am qualified to review the technical information contained in these Supplemental Comments and three Technical Attachments, that I am familiar with Part 25 of the Commission's Rules, that I have reviewed the technical information submitted in this document, and that it is complete and accurate to the best of my knowledge.

My technical qualifications comprise over 40 years of direct experience in satellite systems engineering including 22 years at COMSAT and its subsidiaries. I hold a B.S.E. degree from Princeton University and a M.S.E.E. degree from the University of Maryland. I am a Fellow of IEEE, AIAA, and WAS and have received the APOLLO Achievement Award from NASA for development of the Unified S-Band System, the Army Commendation Medal, and the IEEE Centennial Medal. I hold eight United States patents and have authored over 50 technical papers.

By: Robert D. Briskman
Robert D. Briskman
Executive Vice President—Engineering

Professional Engineer
DC License # 749008279

Date: Jan. 12, 2000

Sworn and subscribed to before me this 12th day of January 2000.

Denise M. Flemm
Notary Public

My Commission Expires:

DENISE M. FLEMM
Notary Public, State of New York
No. 01FL5084199
Qualified in New York County
Commission Expires Sept. 2, 19 2001

EXHIBIT 1

Assessment of Interference Potential from Sirius Satellite Radio (SSR) Terrestrial Transmitters to Wireless Communications Service Systems in Adjacent Frequency Bands Near 2 GHz

Assessment of Interference Potential from Sirius Satellite Radio (SSR) Terrestrial Transmitters to Wireless Communications Systems in Adjacent Frequency Bands near 2 GHz

1. Introduction

FCC Report and Order (FCC 97-50) adopted February 19, 1997 allocated the frequency bands 2310 - 2320 and 2345 - 2360 MHz on a primary basis for fixed, mobile, radio location, and broadcasting-satellite (sound) services. The 2305 - 2310 MHz band was allocated on a primary basis for fixed, mobile except aeronautical mobile, and radio location services. Within these frequency bands, Wireless Communications Service (WCS) licensees will determine the specific services they will provide within their assigned spectrum and geographic areas. This report will address the potential for interference from the out-of-band emissions of Sirius Satellite Radio terrestrial transmitters into fixed and mobile service systems operating in the adjacent bands in two scenarios. The Sirius Satellite Radio out-of-band emission levels are dramatically lower than the FCC rules and significantly (1000 times) lower than the specified out-of-band emission levels for WCS systems. The report will model these WCS systems as accurately as possible given the limited information available and assess the impact of interference into the different types of WCS receivers that may be used.

2. Characteristics of Sirius Satellite Radio Terrestrial Repeaters

The areas for use of Sirius Satellite Radio terrestrial repeaters will be major metropolitan areas and areas where terrain blockage causes the Sirius Satellite Radio receivers to not be able to see a Sirius Satellite Radio satellite. Due to the high elevation angles from the intended receivers to the Sirius Satellite Radio satellites, it is rare for natural terrain to cause an obstruction of the line of sight to the satellites. Thus, dense cities with large buildings are the key areas requiring augmentation of satellite coverage with terrestrial repeaters. Long tunnels, ravines and similar topography will also require additional compensation. Dense cities are obstructers because large clusters of buildings with dissecting roads cause shadowing on multiple sides at very high elevation angles. These dense city environments are mostly located in concentrated areas in each major US city.

These Sirius Satellite Radio terrestrial repeater sites can exploit today's technology and high gain antennas to provide EIRP's up to 40 kilowatts at S-Band. Such sites can provide coverage for ranges of several miles in normal urban environments. The Sirius Satellite Radio terrestrial repeaters will be normally located at heights ranging from 10 meters to 250 meters. These repeaters may be located on the tops of buildings, towers or on hills and the actual height of the transmitters above sea level could be greater than the height of the transmitter above ground level. The characteristics for the Sirius Satellite Radio terrestrial repeaters are given in Table 2-1.

Table 2-1. Characteristics of Sirius Satellite Radio Terrestrial Repeaters (Highest Power Configuration)

Maximum Transmitter Output Power (Watts)	1000.0 (See Note 1)
Maximum Transmitter Output Power (dBW)	30.0
Coupling Losses (dB)	0.5
Transmission Line Losses (dB)	1.5
Maximum Antenna Boresight Gain (dBi)	18.0
Maximum Transmitted E.I.R.P. (dBW)	46.0
Antenna Type	Sectoral - 120° half-power beamwidth
Height above ground	variable
Azimuth	variable
Tilt Angle	variable
Center Frequency (MHz)	2326.25
Bandwidth (MHz)	4.012

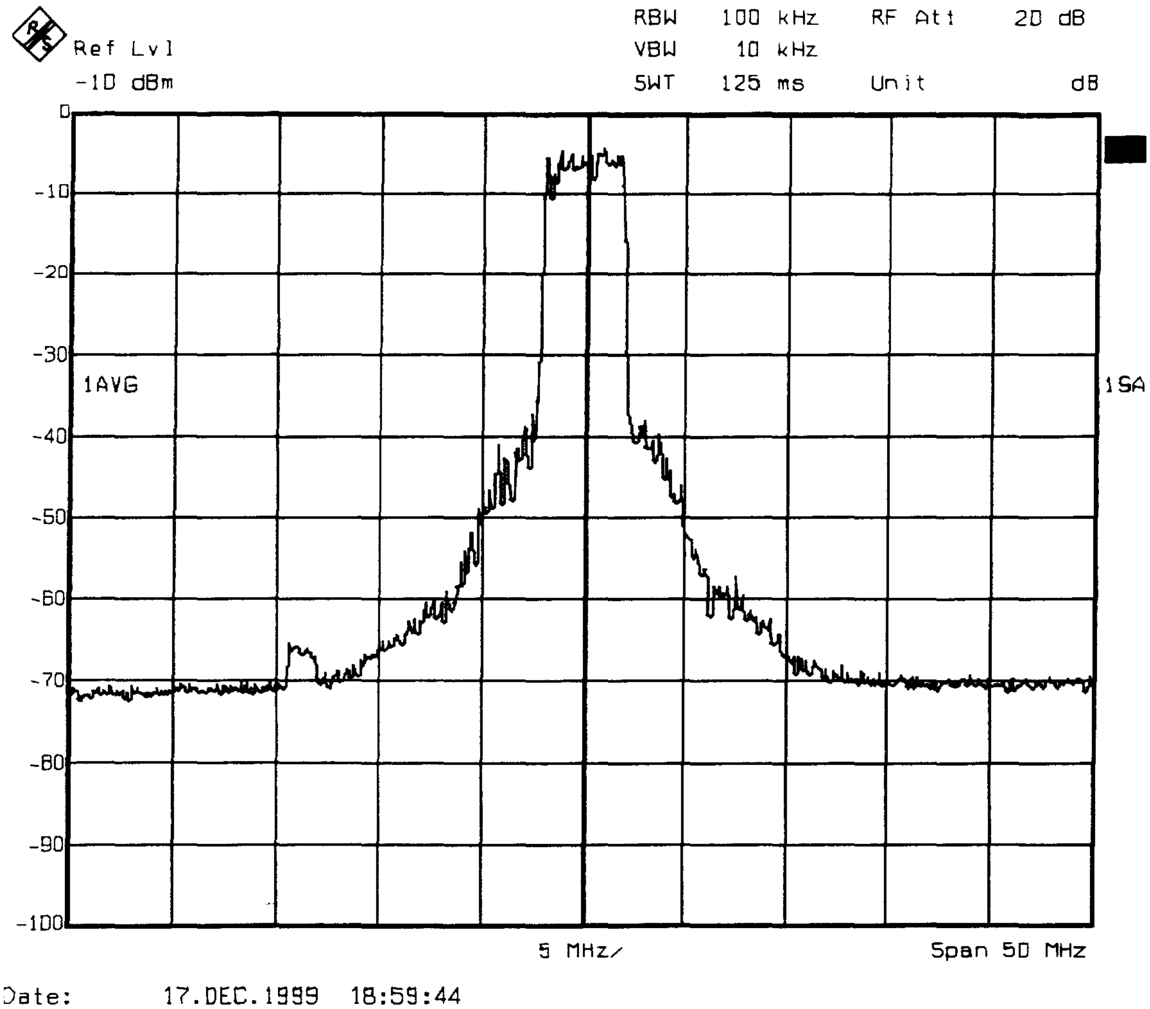
Note 1: Output power of 1000 Watts, as shown in this table, represents the highest power configuration of the Sirius Satellite Radio terrestrial repeaters.

The out-of-band emission levels for the Sirius Satellite Radio terrestrial repeaters are specified in the same format as WCS out-of-band levels, but with much more stringent requirements. The out-of-band emission limits for SDARS terrestrial repeaters are specified to be (75 + 10 log(p)) dB (where p is the EIRP in Watts) less than the transmitter EIRP and are specified in a 1 MHz measurement bandwidth. These out-of-band emissions limits were adopted by the SDARS providers and are more stringent than the emission limits required by the FCC, which vary relative to the frequency separation from the center frequency with the most stringent requirement being (43 + 10 log(tp)) dB (where tp is the transmitter power in Watts).[1] The maximum EIRP spectral density transmitted out-of-band by the Sirius Satellite Radio

[1] CFR 47, Section 25.202 (f): The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule: (1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB; (2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB; (3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts.

terrestrial repeaters is, therefore, 46.0 - (75 + 46.0) = -75 dBW in 1 MHz. Using the characteristics in Table 2-1, the resultant transmitter power spectral density to achieve a maximum EIRP spectral density of -75 dBW in 1 MHz at the band edge (i.e., 2320 MHz) is equal to -91.0 dBW/1 MHz (-91.0 dBW/MHz - 0.5 dB - 1.5 dB + 18.0 dB = -75 dBW/1 MHz). For the purposes of this analysis, it is assumed that this maximum out-of-band emission spectral density is present at any frequency outside of the Sirius Satellite Radio occupied frequency band. In reality, the out-of-band signal power density will roll-off as it is further removed from the Sirius Satellite Radio carrier center frequency and therefore will be lower at frequencies less than 2320 MHz. In the higher WCS band (2345 - 2360 MHz), the closest band edge to the Sirius Satellite Radio occupied frequency band is further removed from the Sirius Satellite Radio carrier center frequency and the interfering transmitted power spectral density will also be lower than that used in this analysis and will further decrease at higher frequencies. The modulated spectrum of Sirius Satellite Radio emissions will roll-off out-of-band at about 2 dBW/MHz as indicated by the typical data provided in Figure 2-1 (note that this depicts the emissions *before* filtering).

Figure 2-1. Example of the Spectrum Roll-Off of the Out-of-Band Emissions of the Sirius Satellite Radio Terrestrial Repeaters



3. Comparison of Sirius Satellite Radio Terrestrial Transmitter Out-of-Band Emission Limits with WCS Out-of-Band Emission Limits

The FCC Report and Order (97-50)(February 19, 1997) (and also the Memorandum Opinion and Order (97-112)(March 31, 1997) specifies the out-of-band emission limits for WCS systems at all frequencies between 2300 and 2320 MHz and between 2345 and 2370 MHz that are outside of the licensed band as: "The power of any emission outside the licensee's bands of operation shall be attenuated below the transmitter power (p) within the licensed bands of operation by not less than 43 + 10*log10(p)". It is further stated that compliance with these provisions is based on the use of measurement instrumentation employing a resolution bandwidth of 1 MHz or less, but at least one percent of the emission bandwidth of the fundamental emission of the transmitter, provided the measured energy is integrated over a 1 MHz bandwidth.

In the Memorandum Opinion and Order, limits were set on the WCS operating powers. WCS fixed, land and radiolocation land stations are limited to 2000 watts peak EIRP and WCS mobile[2] and radiolocation mobile stations are limited to 20 watts peak EIRP. The Memorandum Opinion and Order further states "we believe it is unlikely that, in the foreseeable future, any potential WCS operator would consider employing power levels greater than these limits given the considerable economic cost of developing high power transmitters that would comply with the stringent out-of-band emission limits adopted in this proceeding."

In any given geographical area, there will be multiple WCS licensees. Thus, when designing a WCS system, the out-of-band emissions of other WCS systems must be taken into account. The WCS systems must be designed to operate in an environment with this level of interfering signal power present within its receiving band.

For the WCS example systems used in this analysis, the maximum antenna gains range from 0 dBi to 33 dBi. Using the specified WCS emission limits, the out-of-band emitted spectral power density is -43 dBW/1 MHz. Thus, the out-of-band EIRP spectral density of the WCS systems will range from -43 dBW/MHz to -10 dBW/MHz. Thus, the out-of-band emissions from WCS systems falling within the occupied bandwidth of other adjacent WCS systems will be a minimum of 32 dB higher than the out-of-band emissions from the Sirius Satellite Radio terrestrial repeaters, which is specified to be lower than -75 dBW/1 MHz. This indicates that, since the WCS systems will be designed with enough robustness to protect themselves from the out-of-band emissions of other adjacent WCS systems, the lower out-of-band emissions produced by the Sirius Satellite Radio terrestrial repeaters should not cause any interference problems to the WCS receivers. The SDARS interference limits are, therefore, significantly more stringent than those permitted between WCS licensees and will not impose any significant burden on WCS, MDS or other services.

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[2] The mobile service is defined as a radiocommunication service between mobile and land stations, or between mobile stations. A land station is a station in the mobile service not intended to be used while in motion. See 47 C.F.R. 27.4. A base station is a land station in the land mobile service. See 47 C.F.R. 2.1.

4. Parameters for WCS Systems

WCS systems may be of the fixed service type or the mobile service type. The operating parameters for these systems are to be developed by the WCS licensees and, as such, specific operating parameters for these systems are unknown. For the purposes of this analysis, a range of operating parameters will be used for the WCS systems. For example, maximum antenna gains ranging from 0 dBi to 33 dBi will be used. It will also be assumed that these systems can have bandwidths that range from 1 MHz to 10 MHz.

For this range of characteristics, the expected carrier powers for the assumed WCS links can be calculated using equation (1):

$$C_{received} = P_t + G_t - \text{Path Loss} + G_r \quad \text{(dBW)} \qquad (1)$$

where,

P_t is the WCS transmitter power (in dBW)
G_t is the WCS transmitter antenna gain in the direction of the WCS receiver (in dBi)
Path Loss[3] is calculated as (32.44 + 20*log10(frequency(in MHz)*distance from WCS transmitter to WCS receiver(in km))
G_r is the WCS receiver antenna gain in the direction of the WCS transmitter (in dBi)

Three types of WCS systems are used in this analysis: fixed point-to-point, fixed point-to-multipoint and mobile. For the fixed point-to-point systems, a maximum path length for a given link of 20 km is assumed and the receiving WCS antennas are assumed to be 33 dBi or 20 dBi antennas. For the point-to-multipoint systems, it is assumed that the base station serves an area with a 20 km diameter. This results in the maximum path length for a given link of 10 km. The receiving antennas will have maximum antenna gains of 25 dBi, 20 dBi, and 10 dBi. For the mobile WCS systems, the links are assumed to be a maximum of 1 km and the receive antennas are assumed to be omnidirectional with a gain of either 10 dBi or 0 dBi. For all of the WCS systems it is assumed that the receiving antenna has maximum gain in the direction of the WCS transmitter (i.e., wanted signal is received in the mainbeam). For the purpose of this analysis each of the WCS transmitters is assumed to transmit the maximum allowable power under the FCC rules.

[3] This analysis assumes free space loss. The Hata-suburban propagation model gives a propagation loss that is 30 dB higher for distances on the order of 20 km.

Table 4-1 summarizes the parameters for the different WCS systems and the received carrier powers are also calculated.

Table 4-1. WCS Parameters and Received Carrier Powers

	P-P (1)	P-P (2)	P-MP (1)	P-MP (2)	P-MP (3)	Mobile (1)	Mobile (2)
Transmit EIRP (W)	2000.0	2000.0	2000.0	2000.0	2000.0	20.0	20.0
Transmit EIRP (dBW)	33.0	33.0	33.0	33.0	33.0	13.0	13.0
Path Distance (km)	20.0	20.0	10.0	10.0	10.0	1.0	1.0
Path Loss (dB)	125.8	125.8	119.7	119.7	119.7	99.7	99.7
Receive Antenna Gain (dBi)	33.0	20.0	25.0	20.0	10.0	10.0	0.0
$C_{received}$ (dBW)	-59.8	-72.8	-61.7	-66.7	-76.7	-76.7	-86.7

Although the analysis that follows assumes a 20 watt mobile and a 1 km normal serving area, the same results and conclusions could be drawn for low power portable transmitters (*e.g.,* 0.5 W). This is because all mobile-to-base links operate at about the same required nominal operating signal level (assumed here to be –76.7 dBW). Lower power mobile units achieve the same signal levels as higher power units, albeit at distances closer to the serving base station. In any event, however, the *relative* C/I from an interfering Sirius terrestrial repeater station would be identical.

As can be seen from this table, the range of expected received carrier powers will be from -59 dBW to -87 dBW. For the purposes of this analysis, the point-to-point, point-to-multipoint and mobile system that is the most susceptible to interference (i.e., has the smallest received power) will be used.

5. Description of Analyses

The first part of the analysis will be to calculate the out-of-band interfering signal power that would be received by a WCS system from another WCS system that is operating in an adjacent band and adhering to the FCC out-of-band emission limits. For this analysis, the victim WCS system will be assumed to have the same bandwidth as the interfering WCS system. From this analysis the necessary carrier-to-interference power ratios (C/I) for the WCS systems will be determined.

5.1 Out-of-Band Interference into WCS Systems from other WCS Systems

The interfering signal power received from the out-of-band emissions of a WCS system are calculated using Equation (2):

$$I_{received} = PSD_t + G_t - \text{Path Loss} + G_r \quad \text{(dBW)} \tag{2}$$

where,

PSD_t is the transmitter spectral power density of the WCS transmitter at the band edge of the WCS assignment (in dBW/MHz)
G_t is the interfering WCS transmitter antenna gain in the direction of the victim WCS receiver (in dBi)
Path Loss[4] is calculated as (32.44 + 20*log10(frequency(in MHz)*distance from interfering WCS transmitter to victim WCS receiver(in km))
G_r is the victim WCS receiver antenna gain in the direction of the interfering WCS transmitter (in dBi)

For out-of-band interference from a mobile WCS system into other WCS systems, it is assumed that the victim WCS receiver is located at some distance away from the mobile WCS transmitter (10 meters for this analysis) and the victim WCS receive antenna is pointed directly at the transmitter. With respect to operating in an environment with out-of-band interference from mobile transmitters, it is expected that this situation can occur and the WCS systems would need to be designed to operate in this type of environment. Table 5.1-1 gives the resultant C/I levels in this scenario from a mobile WCS transmitter using a 10 dBi omnidirectional antenna for each of the systems identified in Table 4-1.

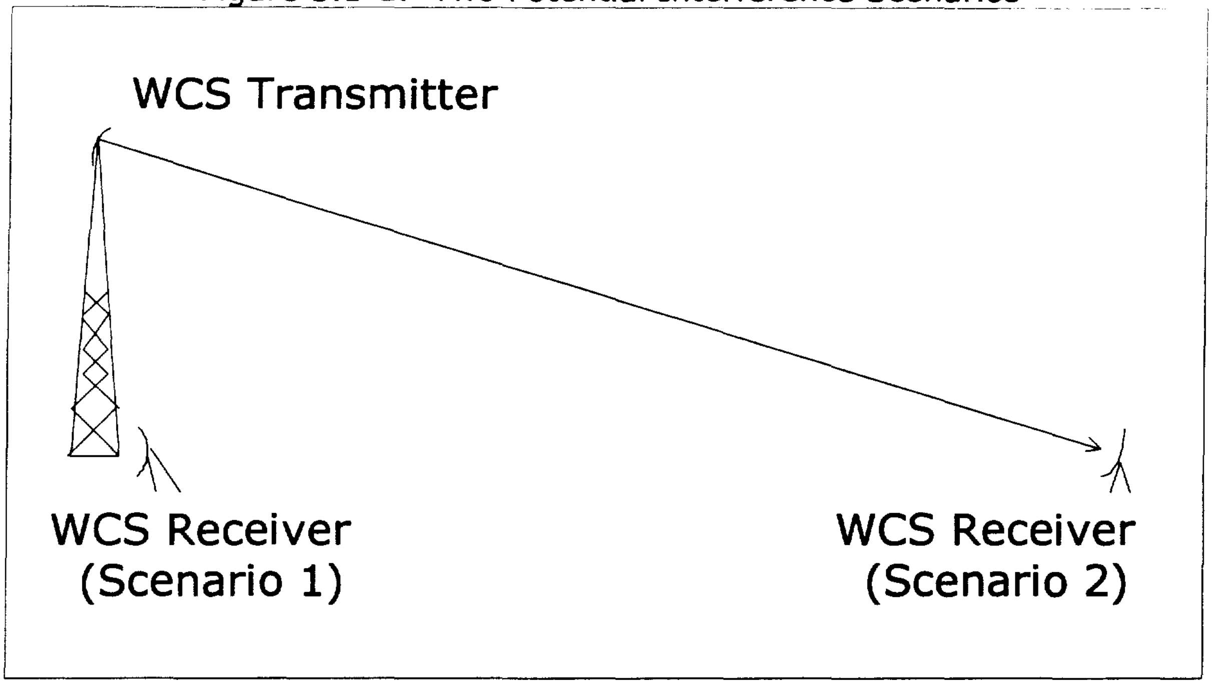
[4] This analysis assumes free space loss. The Hata-suburban propagation model gives a propagation loss that is 30 dB higher for distances on the order of 20 km.

Table 5.1-1. Out-of-Band Interference from Mobile WCS System

	P-P (1)	P-P (2)	P-MP (1)	P-MP (2)	P-MP (3)	Mobile (1)	Mobile (2)
Transmit Power (dBW)	-43.0	-43.0	-43.0	-43.0	-43.0	-43.0	-43.0
Transmit Antenna Gain (dBi)	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Transmit EIRP (dBW)	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0	-33.0
Path Distance (km)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Path Loss (dB)	59.7	59.7	59.7	59.7	59.7	59.7	59.7
Receive Antenna Gain (dBi)	33.0	20.0	25.0	20.0	10.0	10.0	0.0
Interfering Signal Power (dBW)	-59.7	-72.7	-67.7	-72.7	-82.7	-82.7	-92.7
$C_{received}$ (dBW)	-59.8	-72.8	-61.7	-66.7	-76.7	-76.7	-86.7
C/I (dB)	**0.0**	**0.0**	**6.0**	**6.0**	**6.0**	**6.0**	**6.0**

For interference from point-to-point and point-to-multipoint WCS systems, two different scenarios will be investigated. In the first, it is assumed that the interfering WCS transmitter is located on a tower at some height above ground level and the victim WCS receiver is located at the base of the tower that houses the interfering WCS transmitter. In the second scenario, the victim WCS receiver is located directly in the mainbeam of the interfering WCS antenna and the victim antenna is directed at an azimuth and elevation angle such that the mainbeam of the receiver is pointing directly at the interfering WCS transmitter. These two scenarios are shown in Figure 5.1-1.

Figure 5.1-1. Two Potential Interference Scenarios



For the first scenario, the interfering signal will be coming from the sidelobes of the interfering WCS transmit antenna. For this analysis, a transmitting antenna with a 25 dBi antenna will be assumed. The antenna gain (according to ITU-R Recommendation 699) for this antenna in the gain of the victim WCS receiver will be 1.35 dBi. The transmit antenna is assumed to be at a height of 10 meters above the base of the tower. The victim WCS receive antenna will also have some discrimination toward the interfering WCS transmitter. For the point-to-point and first two point-to-multipoint systems, the antenna gain is calculated using ITU-R Recommendation 699. For the last point-to-multipoint system and the two mobile systems, the antenna is assumed to have an omnidirectional pattern (i.e., maximum gain in all directions). The results of this analysis are shown in Table 5.1-2.

Table 5.1-2. Out-of-Band Interference from Point-to-Point or Point-to-Multipoint WCS Systems in Scenario 1

	P-P (1)	P-P (2)	P-MP (1)	P-MP (2)	P-MP (3)	Mobile (1)	Mobile (2)
Transmit Power (dBW)	-43.0	-43.0	-43.0	-43.0	-43.0	-43.0	-43.0
Transmit Antenna Gain (dBi)	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Transmit EIRP (dBW)	-41.7	-41.7	-41.7	-41.7	-41.7	-41.7	-41.7
Path Distance (km)	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Path Loss (dB)	59.7	59.7	59.7	59.7	59.7	59.7	59.7
Receive Antenna Gain (dBi)	-2.7	3.9	1.4	3.9	10.0	10.0	0.0
Interfering Signal Power (dBW)	-104.0	-97.5	-100.0	-97.5	-91.4	-91.4	-101.4
$C_{received}$ (dBW)	-59.8	-72.8	-61.7	-66.7	-76.7	-76.7	-86.7
C/I (dB)	**44.3**	**24.8**	**38.3**	**30.8**	**14.7**	**14.7**	**14.7**

In the second scenario, the victim WCS receiver is located directly in the mainbeam of the interfering WCS transmitter and the victim WCS antenna is directed at an azimuth and elevation angle such that the mainbeam of the receiver is pointing directly at the interfering WCS transmitter. For this analysis, the interfering WCS system is assumed to be using a 25 dBi antenna. The distance between the interfering WCS transmitter and the victim WCS receiver is assumed to be 100 meters. Table 5.1-3 gives the results of this analysis.